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S I R:

Transmitted herewith for filing is: ☒ a new application
[] a c-i-p application of S.N. _____ filed _____

Inventor(s): Kazutomo HASEGAWA; Seiji MIYOSHI; Yutaka AWATA; Takaashi SASAKI; Nobukazu KOIZUMI

For: DIGITAL SUBSCRIBER LINE COMMUNICATING SYSTEM AND A TRANSCEIVER IN THE SYSTEM

Enclosed are:

- ☒ 15 sheets of drawings. (Figs. 1A,1B,2,3,4A,4B,5,-12,13A,13B,14)
- ☒ Specification, including claims and abstract (37 pages)
- ☒ Declaration
- ☒ An assignment of the Invention to FUJITSU LIMITED
- ☐ A certified copy of _____ Application No. _____
- ☒ An associate power of attorney
- ☐ A verified statement to establish small entity status under 37 CFR 1.9 and 37 CFR 1.27
- ☒ Post card
- ☒ Recording fee (as indicated below)
- ☐ Information Disclosure Statement, PTO-1449, copies of _____ references
- ☐ Other _____
- ☐ Other _____

	Col. 1	Col. 2
FOR:	NO. FILED	NO. EXTRA
BASIC FEE		
TOTAL CLAIMS	35-20 =	15
INDEP CLAIMS	10-3 =	7
[] MULTIPLE DEPENDENT CLAIMS PRESENTED		

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SMALL ENTITY	
RATE	FEE
	\$380
x 9 =	\$
x 39 =	\$
x 130 =	\$
TOTAL	\$

OTHER THAN A SMALL ENTITY	
RATE	FEE
	\$760
x 18 =	\$270
x 78 =	\$546
x 260 =	\$
TOTAL	\$1576

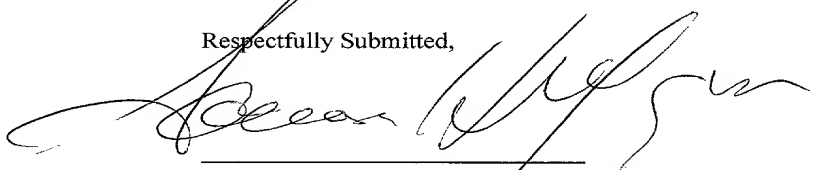
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Helfgott & Karas, P.C.
60th Floor
Empire State Building
New York, New York 10118-6098
(212)643-5000

Respectfully Submitted,



Date: June 18, 1999

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- [] Aaron B. Karas, Reg. No. 18,923
- ☒ Samson Helfgott, Reg. No. 23,072
- [] Leonard Cooper, Reg. No. 27,625
- [] Linda S. Chan, Reg. No. 42,400
- [] Jacqueline Steady, Reg. No. 44,354

THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of: **Kazutomo HASEGAWA et al.**

Filed : **Concurrently herewith**

For : **DIGITAL SUBSCRIBER LINE COMMUNICATING SYSTEM
AND A TRANSCEIVER IN THE SYSTEM**

Serial No.: **Concurrently herewith**

June 18, 1999

Assistant Commissioner of Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT

S I R:

Prior to the issuance of an Office Action, please
amend the application as follows:

IN THE CLAIMS:

Please amend the following claim:

Claim 13, line 2, delete "or claim 8"

Claim 14, line 2, delete "or claim 8"

Claim 15, line 2, delete "or claim 8"

Claim 16, line 2, delete "or claim 8"

R E M A R K S

This amendment has been filed to avoid improper
multiple dependent claims.

DIGITAL SUBSCRIBER LINE COMMUNICATING SYSTEM
AND A TRANSCEIVER IN THE SYSTEM

5 BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a digital subscriber line communicating system and a transceiver in the system which utilize an existing telephone line as a high speed data communication line. More particularly, it relates to an improvement of a modulation/demodulation system in a transmission apparatus used in the above-mentioned communication system.

In recent years, multimedia services such as internet and so forth have expanded through society and into homes. Accompanied by such development, it has been strongly required to promptly provide an economical and reliable digital subscriber line communicating system for utilizing such services.

20 2. Description of the Related Art

(1) An explanation of an ADSL

As a technique to provide a subscriber line communicating system which utilizes the existing telephone line as a high speed data communication line, an xDSL (Digital Subscriber Line) is known. xDSL is a communicating system which utilizes a telephone line and a modulation/demodulation technique. xDSLs are generally classified into a symmetric type and an asymmetric type. In the symmetric type, upstream transmission speed from a subscriber home (hereinafter referred to as a remote terminal side or an RT side) to an accommodating central office (hereinafter referred to as a central office side or a CO side) is symmetric with the transmission speed from the central office side to the remote terminal side. In the asymmetric type, the transmission speed from the remote terminal side to the central office side is asymmetric with the transmission speed from the central

office side to the remote terminal side.

In the asymmetric xDSLs, there is an Asymmetric DSL (ADSL) modem which is provided with the G.DMT standard having a downstream transmission speed of about 6 Mbit/sec. and the G.lite standard having a downstream transmission speed of about 1.5 bits/sec. Both of the G.DMT and G.lite employ Descrete Multitone (DMT) modulation.

(2) An Explanation of the DMT Modulation

DMT modulation will be explained using G.lite as an example. This explanation and the associated drawing will describe only the downstream modulation/demodulation from the central office to the remote terminal. However, DMT modulation is also possible in the upstream modulation/demodulation.

Firstly, transmitting data is input into an ADSL transceiver unit (ATU) in the central office and a one-symbol time (1/4 kHz) of the data is stored in a serial to parallel buffer. The stored data are divided into a plurality of groups. A predetermined number of transmission bits per carrier signal is previously allocated to each group in accordance with a transmitting bitmap which will be described later in detail. Each group is output to an encoder. In the encoder, each group of the input bit series is converted into a signal point expressed by a complex number for an orthogonal amplitude modulation and is output to IFFT. The IFFT performs the conversion from each of the signal points to transmitting signal sequences by an inverse fast Fourier transform. The signals from the IFFT are output to a parallel to serial buffer. Here the sixteen points of the outputs of the IFFT are added as a Cyclic Prefix to the head of each DMT symbol. The output of the parallel to serial buffer is supplied to a D/A converter in which the digital signal with a sampling frequency of 1.104 MHz is converted into an analog signal. The analog signal is transmitted through a metallic line to a remote terminal.

At the remote terminal side, the analog signal is converted into a digital signal with the sampling frequency of 1.104 MHz by an A/D converter. Each DMT symbol of the digital signal is stored in a serial to parallel buffer. In the buffer, the Cyclic Prefix is removed from the digital signal, and the remaining signal is output to an FFT. In the FFT, a fast Fourier transform is effected to generate or demodulate the signal points. The demodulated signal points are decoded by a decoder in accordance with a receiving bitmap having the same values as those in the transmitting bitmap. The decoded data are stored in a parallel to serial buffer as receiving data of bit-sequences.

(3) A Detailed Explanation of the Bitmap

The bitmap described in the explanation of the DMT will be explained in detail with reference to Figs. 13A and 13B.

The apparatus at the central office side and the apparatus at the remote terminal side both measure the ratio of the receiving signal to noise (hereinafter referred to as S/N) during a training period prior to communication to determine the number of bits to be transmitted by each modulating carrier. As shown in Figs. 13A and 13B, for a carrier signal with a larger S/N, a larger number of bits to be transmitted are allocated; and for a carrier signal with a smaller S/N, a smaller number of bits to be transmitted are allocated.

By the above allocation, the receiving side measures the S/N to prepare the bitmap which indicates the numbers of bits to be transmitted corresponding to the carrier numbers.

The receiving side informs this bitmap to the transmitting side during a training period so that both the transmitting side and the receiving side can perform the modulation/demodulation with the use of the same bitmap during normal data communication.

(4) Countermeasure Against Cross-Talk From the
Time Compression Modulation ISDN Transmission
(hereinafter referred to as TCM ISDN Transmission)

5 When there is a cross-talk due to the TCM
ISDN Transmission, in the prior art, two different
bitmaps are used in the ADSL modem in the transmitting
side or in the receiving side so as to improve the
transmission characteristic. This method of using the
two bitmaps will be explained with reference to Fig. 14.

10 In the TCM ISDN transmission, the central
office side transmits downstream data during a prior half
of one cycle of a reference clock signal of 400 Hz shown
in (1) of Fig. 14, in synchronization with the reference
clock signal of 400 Hz; and the remote terminal side
15 receives the downstream data and then transmits upstream
data. Therefore, the ADSL modem in the central office is
influenced by a Near End Cross-Talk (hereinafter referred
to as NEXT) from the downstream ISDN during the prior
half of the one cycle of 400 Hz, and is influenced by a
20 Far End Cross-Talk (hereinafter referred to as FEXT) from
the upstream ISDN during the latter half of one cycle of
400 Hz.

25 Contrary to the central office, the ADSL
modem in the remote terminal is influenced by a FEXT
during a prior half of one cycle of the reference clock
signal of 400 Hz, and is influenced by a NEXT during a
latter half of the cycle.

30 If the metallic cable between the central
office and the remote terminal is long, the S/N of the
receiving signal to the NEXT is made smaller, and in some
cases, the NEXT may be greater than the receiving signal.

35 In these cases, since the influence of the
FEXT is not so large, in the prior art, two bitmaps are
provided. One is a bitmap (DMT symbol X) for receiving
signals during the NEXT period at the remote terminal.
The other is a bitmap (DMT symbol Y) for receiving
signals during the FEXT period at the remote terminal.

During the NEXT period, in the prior art, the number of bits to be transmitted is made small so as to improve the resistance of the signals against the S/N. During the FEXT period, in the prior art, the number of bits to be transmitted is made large so as to increase the transmission capacity.

On the other hand, the time interval of one DMT symbol is usually 246 μ s with a Cyclic Prefix of 16 points. Contrary to this, in the prior art, in order to synchronize the DMT symbols with the TCM Cross-talk period of 400 Hz, the time interval of one DMT symbol is made to be 250 μ s with a Cyclic Prefix of 20 points so that one period of the TCM Cross-talk is made to coincide with the time period of ten DMT symbols, whereby the synchronization with the TCM Cross-talk is established.

(5) FEXT and NEXT

Fig. 2 is a timing chart showing the cross-talk that the ADSL receives from the TCM-ISDN.

The TCM-ISDN transmission is carried out at a frequency of 400 Hz with the period of 2.5 ms as shown in (1) of Fig. 2. During the first half cycle of each period of the TCM-ISDN, the CO side transmits symbols as shown in (2) of Fig. 2 and during the latter half cycle of the period, the RT side transmits symbols as shown in (3) of Fig. 2. In the first half cycle of the period of TCM-ISDN, therefore, the center ADSL unit (ATU-C) is affected by the near end cross-talk ($NEXT_c$) from the TCM-ISDN, and in the latter half cycle, the ATU-C is affected by the far end cross-talk ($FEXT_c$) from the TCM-ISDN as shown in (5) of Fig. 2. On the other hand, the subscriber ADSL unit (ATU-R) is affected by the $FEXT_r$ from the TCM-ISDN during the first half cycle of the one TCM-ISDN period, and by the $NEXT_r$ from the TCM-ISDN during the latter half cycle thereof. In this specification, the time areas affected by NEXT and FEXT in this way will be called the NEXT duration and the FEXT

duration, respectively as shown in (4) and (5) of Fig. 2.

The center ADSL unit (ATU-C) in the CO side can estimate or define the $FEXT_R$ duration and the $NEXT_R$ duration at the subscriber ADSL unit (ATU-R) in the RT side. Also, the ADSL unit (ATU-R) in the RT can estimate or define the $FEXT_C$ duration and the $NEXT_C$ duration at the center ADSL unit (ATU-C) in the CO. That is, each period is estimated or defined as follows.

$FEXT_R$: FEXT duration at ATU-R estimated by ATU-C

$NEXT_R$: NEXT duration at ATU-R estimated by ATU-C

$FEXT_C$: FEXT duration at ATU-C estimated by ATU-R

$NEXT_C$: NEXT duration at ATU-C estimated by ATU-R

The transmission delay is also taken into consideration in these definitions.

(6) Sliding Window

For the purpose of providing a digital subscriber line transmission system capable of transmitting the ADSL signal in satisfactory manner in the cross-talk environment from the TCM-ISDN described above, the present applicant has earlier proposed to introduce a "sliding window" in Japanese Patent Application No. 10-144913 (corresponding to U.S. Patent Application Serial No.: 09/318,445 filed on May 25, 1999) which is incorporated herein by reference.

According to Patent Application No. 10-144913, in the downstream transmission of the ADSL signal from the center ADSL unit (ATU-C) to the subscriber ADSL unit (ATU-R), the state of the ADSL signal transmitted by the center ADSL unit (ATU-C) in the cross-talk environment from the TCM-ISDN is defined as follows.

That is, in the case where the transmission symbol is completely contained in the $FEXT_R$ duration, as shown in Fig. 3, the center ADSL unit (ATU-C) transmits the symbol as an inside symbol by means of the sliding window. Also, in the case where the transmission symbol is included in the $NEXT_R$ duration even partially, the center ADSL unit (ATU-C) transmits

the symbol as an outside symbol.

According to the dual bitmap mode, the center ADSL unit (ATU-C) transmits the inside symbol using a bitmap A for the $FEXT_r$ duration and the outside symbol using a bitmap B for the $NEXT_r$ duration.

Similar to in the downstream transmission, according to the dual bitmap mode the subscriber ADSL unit (ATU-R) transmits the inside symbol using the bitmap A for the $FEXT_c$ duration and transmits the outside symbol using the bitmap B for the $NEXT_c$ duration in the upstream transmission.

Here, there is a case where the center ADSL unit (ATU-C) does not use the bitmap B. This case is a single bitmap mode. In such a case, the center ADSL unit (ATU-C) transmits only the pilot tone outside of the sliding window. In similar fashion, there is case where the subscriber ADSL unit (ATU-R) does not use the bitmap B. This case is also the single bitmap mode. In the single bitmap mode, the subscriber ADSL unit (ATU-R) transmits nothing outside of the sliding window.

As described above, an effective transmission technique under the noise environment from the TCM-ISDN has been proposed, for example, in Japanese Patent Application No. 10-144913 by the present applicant. Nevertheless, a specific training method for the ADSL transceiver in employing such a transmission technique or means for carrying out the training method have yet to be studied.

SUMMARY OF THE INVENTION

The present invention has been developed based on new knowledge and study of the points described above, and the object thereof is to provide a digital subscriber line transmission system and a communication apparatus used for the transmission system accompanied by a specific training method for the ADSL transceiver in employing an effective transmission technique for the ADSL signal under the noise environment from the TCM-ISDN

or including means for carrying out such a training method.

According to the present invention, there is provided a digital subscriber line communicating system for communicating through a communication line, including: means for generating a sliding window based on a timing signal representing a periodical noise duration; and means for discriminating, based on a status of the sliding window, which kind of durations of the periodical noise duration a transmitting data symbol belongs to.

The system may further includes means for performing an initial training of a receiver equalizer according to the status of the sliding window.

Specifically, according to a first aspect of the invention, there is provided a digital subscriber line communicating system for communicating between a transmitting side and a receiving side through a communication line, comprising a sliding window generating unit for generating a sliding window based on a timing signal representing a periodical noise duration, and a sliding window transmitting unit for transmitting modulated symbol according to the sliding window through the communication line to the receiving side.

The sliding window generating unit comprises a hyperframe counter for periodically counting a predetermined number of continuous transmitting modulated symbols constituting a hyperframe synchronized with the timing signal; and a decoder for discriminating, based on the count value output from the hyperframe counter, whether a transmitting data symbol belongs to a far end cross-talk duration at the receiving side or a near end cross-talk duration at the receiving side.

According to a second aspect of the present invention, the hyperframe counter is reset each time when the hyperframe counter counts the predetermined number of continuous transmitting data symbols.

According to a third aspect of the present invention, the transmitting side is a central office and the receiving side is a remote terminal.

5 In this case, the central office comprises: a timing signal generating unit for generating the timing signal synchronized with a periodical noise including the periodical noise duration which interferes with the central office and the remote terminal; a receiver equalizer for example time domain equalizer and a
10 frequency domain equalizer; and a sequencer for effecting a transition of the status of initialization of the central office during an initialization period before starting usual communication.

15 According to the fourth aspect of the present invention, the transmitting side is a remote terminal and the receiving side is a central office.

In this case, the remote terminal comprises: a timing signal generating unit for generating the timing signal synchronized with a periodical noise including the periodical noise duration which interferes the remote
20 terminal and the central office; a receiver equalizer; and a sequencer for effecting a transition of the status of initialization of the remote terminal during an initialization period before starting usual
25 communication.

In both the third and fourth aspects of the present invention, the initialization period includes an activation and acknowledgement sequence, a transceiver training sequence for performing an initial training of
30 the receiver equalizer, a channel analysis sequence for measuring the quality of the communication line, and an exchange sequence for determining the transmitting capacity of the communication line based on the measured quality of the communication line.

35 In both the third and fourth aspects of the present invention, the sequencer effects the transition of the status based on the value counted by said hyperframe

counter.

5 In both the third and fourth aspects of the present invention, during the transceiver training sequence, the exchange sequence, and the channel analysis sequence, the initialization is carried out by transmitting modulated symbols through only the inside of the sliding window.

10 In both the third and the fourth aspects of the present invention, during the transceiver training sequence, the exchange sequence, and the channel analysis sequence except for a quality measuring sequence, the initialization is carried out by transmitting modulated symbols through only inside of sliding window, and during the quality measuring sequence in the channel analysis sequence, the initialization is carried out by
15 transmitting modulated symbols through both the inside and the outside of the sliding window.

20 In both the third and the fourth aspects of the present invention, the system further comprises a sequence transition determining unit for making a transition, in synchronization with the timing signal, from the activation and acknowledgement sequence to the transceiver training sequence or from the transceiver training sequence to the channel analysis sequence.

25 In both the third and the fourth aspects of the present invention, according to a dual bitmap mode, the modulated symbols are transmitted from the transmitting side through both the inside and the outside of the sliding window, and the modulated symbols are used for training of the receiver equalizer by the receiving side
30 only when the receiving side is in a far end cross-talk duration.

35 In both the third and the fourth aspects of the present invention, according to the dual bitmap mode, during the training of the receiver equalizer in the transceiver training sequence, a step size for updating coefficients of the equalizer is made to be zero in the near end cross-talk duration, or to be a value smaller

than the value in the far end cross-talk duration in the
near end cross-talk duration at the receiving side, so
that the transceiver training sequence is carried out
continuously in the far end cross-talk duration and the
5 near end cross-talk duration at the receiving side.

In both the third and fourth aspects of the present
invention, the receiving side comprises: a
synchronization symbol detecting unit for detecting a
synchronization symbol included in each of superframes
10 which constitute the hyperframe; an inverse
synchronization symbol detecting unit for detecting an
inverse synchronization symbol included in the
hyperframe; and an inverting unit for rotating the phase
of each carrier signal of the detected inverse
15 synchronization symbol, except for the carrier signal of
a pilot tone, by substantially 180° to obtain an inverted
inverse synchronization symbol having the same phase as
the phase of each of the detected synchronization
symbols. In this case, the detected synchronization
20 symbols and the inverted inverse synchronization symbol
are used for the training of receiver equalizer.

According to a fifth aspect of the present
invention, there is provided a digital subscriber line
communicating system for communicating between a
25 transceiver in a central office and a transceiver in a
remote terminal through a communication line, wherein,
during timing recover training sequence between the
central office and the remote terminal, an inside symbol
of a downstream sliding window is formed by a first kind
30 of signal, and an outside symbol of the downstream
sliding window is formed by a second kind of signal. In
this case, the first kind of signal and the second kind
of signal are obtained by modulating a carrier signal but
are different in phase by a predetermined angle. The
35 transceiver in the remote terminal recognizes whether a
received symbol belongs to a far end cross-talk duration
at the remote terminal or a near end cross-talk duration

at the remote terminal, by detecting the phase of the output of a fast Fourier transform of the carrier signal, so as to recognize the phase of a timing signal which represents a periodical noise duration.

5 According to a sixth aspect of the present invention, a quadrature phase shift keying demodulation is employed to recognize the phase of a timing signal.

10 According to a seventh aspect of the present invention, there is provided a digital subscriber line communicating system for communicating between a central office and a remote terminal; the central office comprising: a phase-locked loop circuit for synchronizing a network timing reference signal, having a frequency higher than the frequency of a first timing
15 signal, with an oscillating signal of a crystal oscillator provided in the central office, to generate a master clock signal; and a timing signal regenerating circuit for shifting the phase of the first timing signal to provide a synchronization in phase with the phase of
20 the master clock signal so as to generate a second timing signal to be used in the central office.

25 According to an eighth aspect of the present invention, there is provided a transceiver to be connected through a communication line, having the same features as in the above-described system.

BRIEF DESCRIPTION OF THE DRAWINGS

30 The above objects and features of the present invention will be more apparent from the following description of the preferred embodiments with reference to the accompanying drawings, wherein:

Fig. 1A is a block diagram showing a central office according to an embodiment of the present invention;

Fig. 1B is a block diagram showing a remote terminal according to an embodiment of the present invention;

35 Fig. 2 is a timing chart of the TCM-ISDN cross-talk;

Fig. 3 is a diagram showing a sliding window;

Figs. 4A and 4B are a diagram schematically showing

timing charts for initialization;

Fig. 5 is a block diagram showing a sliding window generating unit and a sequencer according to an embodiment of the invention;

5 Fig. 6 is a diagram showing the QPSK demodulation;

Fig. 7 is a block diagram showing a reference model of the ATU-C transmitter;

Fig. 8 is a diagram showing a reference clock signal generating unit in the ATU-C;

10 Fig. 9 is a diagram showing a transmission pattern of SWB method at the central office side;

Fig. 10 is a pattern showing a transmission pattern of SWB method at the remote terminal side;

15 Fig. 11 is a diagram showing a signal modulating point during timing recover sequence;

Fig. 12 is a diagram showing the SWB method in the case where two bitmaps are used;

Figs. 13A and 13B are diagrams showing the definition of a bitmap; and

20 Fig. 14 is a diagram showing a conventional signal structure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of the present invention will be described below with reference to the drawings.

25 Fig. 1A is a block diagram showing functional blocks of a central office according to an embodiment of the present invention; and Fig. 1B is a block diagram showing functional blocks of a remote terminal according to an embodiment of the present invention.

30 As shown in Fig. 1A, the central office includes a reference clock signal generating unit 1, a sliding window generating unit 2, a sequencer 3, and a sliding window transmitting unit 4. The reference signal generating unit 1 generates a reference clock signal
35 having a frequency of, for example, 400 Hz, synchronized with a TCM ISDN transmission which interferes with the central office and the remote terminal. The reference

clock signal may be generated based on an external signal or with an internal signal generated by a crystal oscillator as an example.

5 The sliding window generating unit 2 generates a downstream sliding window from the generated reference clock signal. The downstream sliding window discriminates whether the transmitting DMT symbols are received in a far end cross-talk duration or in the other duration at the remote terminal. The discriminated
10 result is sent to the sliding window transmitting unit 4.

 The sequencer 3 controls a sequence transition in the central office during an initialization period of the communicating system.

15 The sliding window transmitting unit 4 transmits the DMT symbols according to the downstream sliding window to the remote terminal.

 As shown in Fig. 1B, the remote terminal includes a sliding window receiving unit 5, a reference clock signal generating unit 6, a sliding window generating unit 7,
20 and a sequencer 8.

 The sliding window receiving unit 5 receives the DMT symbol, according to the downstream sliding window from the central office.

25 The reference clock signal generating unit 6 generates a reference clock signal from received DMT symbols which are transmitted from the central office according to the sliding window.

30 The sliding window generating unit 7 generates a downstream sliding window from the generated reference clock signal by the reference clock signal generating unit 6. The generated downstream sliding window defines whether the received DMT symbols are received in a far end cross-talk duration or other duration at the remote terminal.

35 The sequencer 8 controls a sequence transition in the remote terminal during the initialization period of the communicating system.

The reference clock signal in the central office may be generally referred to as a timing signal which is synchronized with the transmission system which interferes with the central office and the remote terminal.

DMT modulation will be explained using the G.lite as an example and with reference to Figs. 1A and 1B. This explanation and the associated drawings will describe only the downstream modulation/demodulation from the central office to the remote terminal. However, the DMT modulation is also possible in the upstream direction.

Firstly, transmitting data is input into an ADSL transceiver unit (ATU) in the central office and a one-symbol time (1/4 kHz) of the data is stored in a serial to parallel buffer 10. The stored data are divided into a plurality of groups. A predetermined number of transmission bits b_0, \dots, b_i per a carrier signal is previously allocated to each group in accordance with a transmitting bitmap 60 which will be described later in detail. Each group is output to an encoder 20. In the encoder 20, each group of the input bit series is converted into a signal point expressed by a complex number for an orthogonal amplitude modulation and is output to IFFT 30. The IFFT 30 performs the conversion from each of the signal points to transmitting signal sequence by an inverse fast Fourier transform. The signals from the IFFT 30 are output to a parallel to serial buffer 40. Here the sixteen tail points 240 - 255 of the outputs of the IFFT 30 are added as a Cyclic Prefix to the head of each DMT symbol. The output of the parallel to serial buffer 40 is supplied to a D/A converter 50 in which the digital signal with a sampling frequency of 1.104 MHz is converted into an analog signal. The analog signal is transmitted through a metallic line 100 to a remote terminal.

At the remote terminal side, the analog signal is converted into a digital signal with a sampling frequency

of 1.104 MHz by an A/D converter 110. Each DMT symbol of the digital signal is stored in a serial to parallel buffer 120. In the buffer 120, the Cyclic Prefix is removed from the digital signal, and the remaining signal is output to an FFT 130. In the FFT 130, a fast Fourier transform is effected to generate or demodulate the signal points. The demodulated signal points are decoded by a decoder 140 in accordance with a receiving bitmap 160 having the same values as those in the transmitting bitmap 60. The decoded data are stored in a parallel to serial buffer 150 as receiving data of bit-sequences b0, ..., and bi.

In the following, an initialization, a sliding window generating unit and a sequencer, a transceiver training, and an inverse synchronization symbol will be described.

(1) Initialization

Figs. 4A and 4B schematically show timing charts for the initialization of the ADSL transceivers ATU-C and ATU-R. The initialization period includes an activation and acknowledgement sequence for determining whether a dual bitmap mode or a single bitmap mode should be used in the central office or in the remote terminal, a transceiver training sequence for performing an initial training of the central office or the remote terminal, a channel analysis sequence for measuring the quality of said communication line, and an exchange sequence for determining the transmitting capacity of the communication line based on the measured quality of said communication lines, and for informing the transmitting capacity to each other. The channel analysis sequence includes a C-MEDLEY in the ATU-C and an R-MEDLEY in the ATU-R. The C-MEDLEY and the R-MEDLEY are sequences for measuring S/N. At the time of ADSL training, it is important to send out ADSL signals only during the period when the NEXT noise for the TCM-ISDN is not generated at the TCM-ISDN receiving side, taking the effect on the

TCM-ISDN into account for both upstream and downstream transmission. For this reason, as shown in Figs. 4A and 4B, during the transceiver training and exchange sequence, the initialization is performed according to the single bitmap mode. Also, during the channel analysis sequence, the initialization is performed according to the single bitmap mode for the sequences other than the C-MEDLEY and the R-MEDLEY. During the C-MEDLEY and the R-MEDLEY, on the other hand, the line quality is checked, that is, S/N is measured by both the inside and outside symbols according to a dual bitmap mode, or by the inside symbol only according to a single bitmap mode.

(2) Sliding Window Generating Unit and Sequencer

Fig. 5 shows the construction of the sliding window generating unit 2 or 7 in Fig. 1A or 1B, and the construction of the sequencer 3 or 8 in Fig. 1A or 1B, according to an embodiment of the present invention.

The sliding window generating unit and sequencer shown in Fig. 5 is included in each of the center ADSL unit (ATU-C) and the subscriber ADSL unit.

As shown in Fig. 5, the sliding window generating unit includes a hyperframe counter 501, a sliding window decoder 503, and the sequencer includes a symbol number counter 505, a transition condition logic unit 507, a comparator 509, a sequence counter 511, a count value decoder 513, and an initialization decoder 515. The timing signal (400Hz) 517 is provided from the reference clock generating unit 1 or 6 in Fig. 1A or 1B. The DMT symbol clock 519 has a period of one DMT symbol time. The sequence transition information 521 is an external condition for sequence transition (for example, activation signal detection flag, etc.). The FEXT/NEXT signal 523 represents inside or outside of the sliding window. The initialization information signal control the transmitting unit and receiving unit according to initialization sequence.

In operation, the hyperframe counter 501 counts the number of DMT symbols by counting the DMT symbol clocks 519 a predetermined number of times (for example, 345 times) continuously. Using this count value, the
5 sliding window decoder 503 discriminates whether a transmitting or receiving DMT symbol belongs to a $FEXT_R$, $NEXT_R$, $FEXT_c$ or $NEXT_c$ duration in the sliding window.

Also, the center ADSL unit ATU-C starts the C-REVEILLE (the first sequence of downstream transceiver
10 training sequence) and C-RATES1 (the first sequence of downstream channel analysis sequence), and the subscriber ADSL unit ATU-R starts the R-REVERB3 (the first sequence of upstream channel analysis sequence), respectively, synchronized in phase with the timing signal 517 having a
15 frequency of 400 Hz. This can be realized by making the 400 Hz timing signal 517 as the condition for sequence transfer in the transition condition logic unit 507 and by clearing the hyperframe counter 501 in response to the timing signal. The symbol number counter 505 counts the
20 number of DMT symbols by counting the DMT symbol clocks 519, and by making the comparison with the number of the DMT symbols output from the count decoder 513 as a condition for sequence transfer in the transition condition logic unit 507, the number of DMT symbols is
25 the length of each sequence in the initialization period. Also, the sequence transition information 521 is input as a sequence transition condition into the transition condition logic unit 507. When the sequence transition occurs, the transition condition logic unit 507 outputs
30 an enable signal to the enable terminal EN of the sequence counter 511. Thus, the sequence counter 511 increments its count each time when the sequence in the initialization period transfers from one sequence to the next sequence. The count value decoder 513 decodes the
35 count value output from the sequence counter 511 to output the number of the DMT symbols corresponding to the count value, i.e., the length of the sequence. The count

value output from the sequence counter 511 is also input to the initialization decoder 515. The initialization decoder 515 generates an initialization information 525 to control the transmitting unit and receiving unit, for example, determining the initialization signals such as the C-REVEILLE and the C-PILOT1 (timing recovery training signals in transceiver training sequence), etc. to be transmitted or to be received.

The above-described configuration has been described as realized with hardware, however, it can also be realized in software with a similar configuration.

Also, in the C-PILOT1, the phase of the TCM-ISDN timing signal of 400 Hz is notified from the center ADSL unit (ATU-C) to the subscriber ADSL unit (ATU-R), which in turn detects and converts it into a timing signal having a frequency of 400 Hz by the reference clock signal generating unit 6 in Fig. 1B. In this method, though described in detail later, the subscriber ADSL unit (ATU-R) can periodically detect cross-talk duration of TCM-ISDN.

(3) Transceiver Training Sequence

The transceiver training sequence includes a timing recovery training sequence, an automatic gain control AGC training sequence, equalizer training sequence such as a time domain equalizer TEQ, a frequency domain equalizer FEQ, and a training sequence for frame synchronization. These trainings are performed when a pseudo random signal such as a synchronization symbol S is repeatedly sent out by the ADSL transceiver. In the transceiver training sequence, the initialization is performed according to a single bitmap mode in which synchronization symbols are transmitted and received only in the $FEXT_R$ or $FEXT_C$ duration, so that the transceiver training sequence is performed only in the $FEXT_R$ or $FEXT_C$ duration as a matter of course.

It should be noted that there may be a case in which, in the initialization in the transceiver training

sequence, even when training symbols are transmitted according to a dual bitmap mode in which the training symbols are transmitted in both inside and outside of the sliding window, the receiving side may use the training symbols only inside of the sliding window for training the equalizer.

In the equalizer training sequence in the transceiver training sequence, a step size for updating coefficients of the equalizer such as TEQ and FEQ in the NEXT_r or NEXT_c duration is made to be zero or to be a very small value smaller than the value in the FEXT_r or FEXT_c duration, so that the equalizer training sequence is carried out continuously whether the training symbol is transmitted both inside and outside of the sliding window.

(4) Inverse synchronization symbol

As shown in Figs. 9 and 10, each hyperframe contains one inverse synchronization symbol I. In each equalizer training, however, the inverse synchronization symbol I is also used in combination with the synchronization symbol S in the following manner in order to improve the convergence rate.

Upon receipt of the inverse synchronization symbol I at the receiving side, the phase of each carrier except for the pilot tone is rotated by an inverter 135 by 180 degrees after the fast Fourier transform by the FET 130 shown in Fig. 1B. As a result, the same state is realized as when the synchronization symbol S is received. Then, the training is carried out using the synchronization symbol S generated at the receiving side.

For watching or re-synchronizing the superframe or the hyperframe synchronization, in the case where the synchronization symbol S is detected, the detection is checked with the next inverse synchronization symbol I, and in the case where the inverse synchronization symbol I is detected, on the other hand, the detection is checked with the next detected synchronization symbol S.

(5) Method of Informing the Phase of TCM-ISDN Timing Signal With 400 Hz From Center ADSL Unit (ATU-C) to Subscriber ADSL unit (ATU-R)

5 A method for informing the phase of TCM-ISDN timing signal with 400 Hz from the center ADSL unit (ATU-C) to the subscriber ADSL unit (ATU-R) is described in detail below.

10 In addition to the pilot tone, the C-PILOT1 transmits an i-th carrier belonging to the frequency band with small cross-talk from TCM-ISDN. The i-th carrier may be, for example, 74th carrier having a frequency of 319.125 kHz. The phase of TCM-ISDN timing signal with 400 Hz is informed from the center ADSL unit (ATU-C) to the subscriber ADSL unit (ATU-R) in the i-th carrier
15 using 4-quadrature amplitude modulation (QAM) in the manner described below. This informing process is shown in Fig. 11 and table 1 below.

[Table 1]

DURATION	BIT SEQUENCE BEFORE MODULATION	PHASE AFTER MODULATION
FEXT _R DURATION (BITMAP A)	{0, 0}	(++)
NEXT _R DURATION (BITMAP B)	{0, 1}	(+-)

20 As can be seen from Fig. 11 and the table 1, the two bits {0, 0} in the FEXT_R duration are modulated to (++) which represents the first quadrant; and the two bits {0, 1} in the NEXT_R duration are modulated to (+-) which represents the fourth quadrant.

25 The subscriber ADSL unit (ATU-R) receives the i-th carrier sent thereto from the center ADSL unit (ATU-C) and recognizes the phase of the TCM-ISDN timing signal with 400 Hz by either of the two methods described below.

30 (i) Method of Recognizing the Phase of the TCM-ISDN Timing Signal With 400 Hz by Performing a Fast Fourier Transform

The subscriber ADSL unit (ATU-R), after

receiving the i -th carrier, executes the fast Fourier transform by the FFT 130 shown in Fig. 1B. From the phase of this FFT output, it recognizes whether the carrier belongs to the $FEXT_R$ duration or the $NEXT_R$ duration. The subscriber ADSL unit recognizes the phase of the TCM-ISDN timing signal of 400 Hz using this information.

In this method, however, the subscriber ADSL unit (ATU-R) can recognize the phase of the TCM-ISDN timing signal of 400 Hz only with a relatively low accuracy. The following method is effective for achieving a higher accuracy.

(ii) Method of Recognizing the Phase of the TCM-ISDN Timing Signal with 400 Hz by Carrying Out QPSK Demodulation

The subscriber ADSL unit (ATU-R) executes the QPSK demodulation as shown in Fig. 6 after receiving the i -th carrier. From this result, it recognizes that the receiving signal belongs to the $FEXT_R$ duration or the $NEXT_R$ duration. Using this information, the subscriber ADSL unit (ATU-R) recognizes the phase of the TCM-ISDN timing signal with 400 Hz.

This method makes it possible for the subscriber ADSL unit (ATU-R) to recognize the phase of the TCM-ISDN timing signal with 400 Hz with a high accuracy.

(6) Method of Configuring PLL of TCM-ISDN 400 Hz Burst Clock

Fig. 7 shows a reference model of the ATU-C transmitter. As shown in Fig. 7, the center ADSL unit (ATU-C) is kept supplied with a signal of 8 kHz clock called NTR (network timing reference) from an external source. The signal of the TCM-ISDN timing signal with 400 Hz may also be supplied from an external source. The TCM-ISDN timing signal with 400 Hz may alternatively be generated in the center ADSL unit (ATU-C) without being supplied from an external source (see Japanese Patent

Application No. 10-115223, for example). In this process, the TCM-ISDN timing signal with 400 Hz and the 8 kHz NTR are synchronized in frequency with each other.

Fig. 8 shows a reference clock signal generating unit in the ATU-C, according to a further embodiment of the present invention.

In Fig. 8, the NTR signal having a frequency of 8 kHz is applied to an analog PLL circuit 703. An oscillating signal of 17.664 MHz is generated from a crystal oscillator 704. By the analog PLL circuit 703, the oscillating signal from the crystal oscillator 704 is synchronized in phase with the NTR signal, so that the analog PLL circuit 703 outputs a master clock signal of 17.664 MHz. The frequency of the master clock signal is divided by a frequency divider 705 so that a sampling clock signal 708 with 1.104 MHz for A/D converters or D/A converters is obtained. The master clock signal is also applied to a timing signal regenerating circuit 707 in which the phase of the TCM-ISDN timing signal 702 is shifted to make a synchronization in phase with the phase of the master clock signal. Thus, the internal timing signal 709 having the frequency of 400 Hz is obtained.

In the preceding art, the TCM-ISDN timing signal 702 of 400 Hz is input to the analog PLL circuit 703 in the center ADSL unit (ATU-C), and is synchronized with the oscillating signal from the VCXO 704 therein. The oscillation frequency of the VCXO of the center ADSL unit (ATU-C) is 17.664 MHz for example. In such a case, in order to synchronize the signal from the VCXO 704 with the TCM-ISDN timing signal of 400 Hz, the phase comparison information is acquired once for each 44160 times ($17.664 \text{ M}/400$) for PLL sync operation. Normally, the more the number of phase comparisons, the smaller the phase jitter or the frequency error. The phase comparison conducted once for each 44160 times with the clock of 17.664 MHz, however, normally increases the phase jitter and the frequency error greatly.

In order to avoid this, according to this embodiment, the NTR signal 701 with 8 kHz synchronized with the TCM-ISDN timing signal of 400 Hz which is always supplied to the center ADSL unit (ATU-C) from an external source is used to perform the PLL synchronization operation of VCXO in the center ADSL unit (ATU-C). Thus, the number of times of the phase comparison increases 20 times as large as for the TCM-ISDN timing signal with 400 Hz. Thus, the phase comparison information is obtained at the rate of once for each 2208 times, thereby making it possible to reduce the phase jitter and the frequency error.

The embodiments of the invention described above represent only an example, and other many modifications are conceivable. In any way, however, the present invention has, of course, the same effect.

It will thus be understood from the foregoing detailed description that according to this invention, there are provided a specific training method for the ADSL transceiver in employing an effective transmission technique for the ADSL signal in the noise environment from the TCM-ISDN or a digital subscriber line transmission system and a communication apparatus comprising means for carrying out the particular training method.

WHAT IS CLAIMED IS:

1. A digital subscriber line communicating system for communicating between a transmitting side and a receiving side through a communication line, comprising:

5 a sliding window generating unit for generating a sliding window based on a timing signal representing a periodical noise duration; and

a sliding window transmitting unit for transmitting modulated symbol according to said sliding window through said communication line to said receiving side;

said sliding window generating unit comprising:

15 a hyperframe counter for periodically counting a predetermined number of continuous transmitting modulated symbols constituting a hyperframe synchronized with said timing signal; and

20 a decoder for discriminating, based on the count value output from said hyperframe counter, whether a transmitting data symbol belongs to a far end cross-talk duration at said receiving side or a near end cross-talk duration at said receiving side.

2. The digital subscriber line communicating system according to claim 1, wherein said hyperframe counter is reset each time when said hyperframe counter counts said predetermined number of continuous transmitting data symbols.

3. The digital subscriber line communicating system according to claim 1, wherein said transmitting side is a central office and said receiving side is a remote terminal;

said central office comprising:

35 a timing signal generating unit for generating said timing signal synchronized with a periodical noise including said periodical noise duration which interferes with said central office and said remote terminal;

a receiver equalizer; and

a sequencer for effecting a transition of the status of initialization of said central office during an initialization period before starting usual communication, said initialization period including an activation and acknowledgement sequence, a transceiver training sequence for performing an initial training of said receiver equalizer, a channel analysis sequence for measuring the quality of said communication line, and an exchange sequence for determining the transmitting capacity of said communication line based on the measured quality of said communication line.

4. The digital subscriber line communicating system according to claim 3, wherein, said sequencer effects the transition of the status based on the value counted by said hyperframe counter.

5. The digital subscriber line communicating system according to claim 3, wherein, during said transceiver training sequence, said exchange sequence, and said channel analysis sequence, said initialization is carried out by transmitting modulated symbols through only the inside of said sliding window.

6. The digital subscriber line communicating system according to claim 3, wherein, during said transceiver training sequence said exchange sequence, and said channel analysis sequence except for a quality measuring sequence, said initialization is carried out by transmitting modulated symbols through only the inside of said sliding window, and during said quality measuring sequence in said channel analysis sequence, said initialization is carried out by transmitting modulated symbols through both the inside and the outside of said sliding window.

7. The digital subscriber line communicating system according to claim 3, further comprising:

a sequence transition determining unit for making a transition, in synchronization with said timing

signal, from said activation and acknowledge sequence to said transceiver training sequence or from said transceiver training sequence to said channel analysis sequence.

5 8. The digital subscriber line communicating system according to claim 1, wherein said transmitting side is a remote terminal and said receiving side is a central office;

 said remote terminal comprising:

10 a timing signal generating unit for generating said timing signal synchronized with a periodical noise including said periodical noise duration which interferes with said remote terminal and said central office;

15 a receiver equalizer; and

 a sequencer for effecting a transition of the status of initialization of the status of said remote terminal during an initialization period before starting usual communication, said initialization period including
20 an activation and acknowledgement sequence, a transceiver training sequence for performing an initial training of said receiver equalizer, a channel analysis sequence for measuring the quality of said communication line, and an exchange sequence for determining the transmitting
25 capacity of said communication line based on the measured quality of said communication line.

 9. The digital subscriber line communicating system according to claim 8, said sequencer effects the transition of the status based on the value counted by
30 said hyperframe counter.

 10. The digital subscriber line communicating system according to claim 8, wherein, according to a single bitmap mode, during said transceiver training sequence, said exchange sequence, and said channel
35 analysis sequence, said initialization is carried out by transmitting modulated symbols through only the inside of said sliding window.

11. The digital subscriber line communicating system according to claim 8, wherein, according to a dual bitmap mode, during said transceiver training sequence, said exchange sequence, and said channel analysis sequence except for a quality measuring sequence, said initialization is carried out by transmitting modulated symbols through only the inside of sliding window, and during said quality measuring sequence in said channel analysis sequence, said initialization is carried out by transmitting modulated symbols through both the inside and the outside of sliding window.

12. The digital subscriber line communicating system according to claim 8, further comprising:
a sequence transition determining unit for making a transition, in synchronization with said timing signal, from said activation and acknowledgement sequence to said transceiver training sequence or from said transceiver training sequence to said channel analysis sequence.

13. The digital subscriber line communicating system according to claim 3 or 8, wherein, according to a dual bitmap mode, said modulated symbols are transmitted from said transmitting side through both the inside and the outside of said sliding window, and said modulated symbols are used for training of said receiver equalizer by said receiving side only when said receiving side is in a far end cross-talk duration.

14. The digital subscriber line communicating system according to claim 3 or 8, wherein, according to said dual bitmap mode, during the training of said receiver equalizer in said transceiver training sequence, a step size for updating coefficients of said receiver equalizer is made to be zero in said near end cross-talk duration, or to be a value smaller than the value in said far end cross-talk duration in said near end cross-talk duration at said receiving side, so that said transceiver training sequence is carried out continuously in said far

end cross-talk duration and said near end cross-talk duration at said receiving side.

15. The digital subscriber line communicating system according to claim 3 or 8, wherein said receiving side comprises:

a synchronization symbol detecting unit for detecting a synchronization symbol included in each of superframes which constitute said hyperframe;

an inverse synchronization symbol detecting unit for detecting an inverse synchronization symbol included in said hyperframe; and

an inverting unit for rotating the phase of each carrier signal of the detected inverse synchronization symbol, except for the carrier signal of a pilot tone, by substantially 180° to obtain an inverted inverse synchronization symbol having the same phase as the phase of each of the detected synchronization symbols;

the detected synchronization symbols and the inverted inverse synchronization symbol being used for the training of said receiver equalizer.

16. The digital subscriber line communicating system according to claim 3 or 8, wherein for watching or re-synchronizing the superframe or the hyperframe synchronization, in the case where the synchronization symbol is detected at the receiving side, the synchronization is checked with detection of the next inverse synchronization symbol, and in the case where the inverse synchronization symbol is detected, on the other hand, the synchronization is checked with the next detected synchronization symbol.

17. A digital subscriber line communicating system for communicating between a transceiver in a central office and a transceiver in a remote terminal through a communication line, wherein, during timing recover training sequence between said central office and said remote terminal, an inside symbol of a downstream sliding

window is formed by a first kind of signal, and an outside symbol of said downstream sliding window is formed by a second kind of signal, said first kind of signal and said second kind of signal being obtained by modulating a carrier signal but being different in phase by a predetermined angle, and

said transceiver in said remote terminal recognizes whether a received symbol belongs to a far end cross-talk duration at said remote terminal or a near end cross-talk duration at said remote terminal, by detecting the phase of the output of a fast Fourier transform of said carrier signal, so as to recognize the phase of a timing signal which represents a periodical noise duration.

18. A digital subscriber line communicating system for communicating between a transceiver in a central office and a transceiver in a remote terminal through a communication line, wherein, during timing recover training sequence between said central office and said remote terminal, an inside symbol of a downstream sliding window is formed by a first kind of signal, and an outside symbol of said downstream sliding window is formed by a second kind of signal, said first kind of signal and said second kind of signal being obtained by modulating a carrier signal but being different in phase by a predetermined angle, and

said transceiver in said remote terminal recognizes whether a received symbol belongs to a far end cross-talk duration at said remote terminal or a near end cross-talk duration at said remote terminal, by detecting the phase of the output of a quadrature phase shift keying demodulation of said carrier signal, so as to recognize the phase of a timing signal which represents a periodical noise duration.

19. A digital subscriber line communicating system for communicating between a central office and a remote terminal;

said central office comprising;
a phase-locked loop circuit for
synchronizing a network timing reference signal, having a
frequency higher than the frequency of a first timing
5 signal, with an oscillating signal of a crystal
oscillator provided in said central office, to generate a
master clock signal; and

a timing signal regenerating circuit for
shifting the phase of said first timing signal to provide
10 a synchronization in phase with the phase of said master
clock signal so as to generate a second timing signal to
be used in said central office.

20. A transceiver to be connected through a
communication line, comprising:

15 a sliding window generating unit for
generating a sliding window based on a timing signal
representing a periodical noise duration; and

a sliding window transmitting unit for
transmitting modulated symbol according to said sliding
20 window through said communication line to said receiving
side;

said sliding window generating unit
comprising:

a hyperframe counter for periodically
25 counting a predetermined number of continuous
transmitting modulated symbols constituting a hyperframe
synchronized with said timing signal; and

a decoder for discriminating, based on the
count value output from said hyperframe counter, whether
30 a transmitting data symbol belongs to a far end cross-
talk duration at said receiving side or a near end cross-
talk duration at said receiving side.

21. The transceiver according to claim 20, wherein
said hyperframe counter is reset each time when said
35 hyperframe counter counts said predetermined number of
continuous transmitting data symbols.

22. The transceiver according to claim 20, further

comprising:

a timing signal generating unit for
generating said timing signal synchronized with a
periodical noise including said periodical noise duration
5 which interferes with said transmitting data symbol;

a receiver equalizer; and

a sequencer for effecting a transition of
the status of initialization of said transceiver during
an initialization period before starting usual
10 communication, said initialization period including an
activation and acknowledgement sequence, a transceiver
training sequence for performing an initial training of
said receiver equalizer, a channel analysis sequence for
measuring the quality of said communication line, and an
15 exchange sequence for determining the transmitting
capacity of said communication line based on the measured
quality of said communication line.

23. The transceiver according to claim 22, wherein,
said sequencer effects the transition of the status based
20 on the value counted by said hyperframe counter.

24. The transceiver according to claim 22, wherein,
during said transceiver training sequence, said exchange
sequence, and said channel analysis sequence, said
initialization is carried out by transmitting modulated
25 symbols through only the inside of said sliding window.

25. The transceiver according to claim 22, wherein,
during said transceiver training sequence said exchange
sequence, and said channel analysis sequence except for a
quality measuring sequence, said initialization is
30 carried out by transmitting modulated symbols through
only the inside of said sliding window, and during said
quality measuring sequence in said channel analysis
sequence, said initialization is carried out by
transmitting modulated symbols through both the inside
35 and the outside of said sliding window.

26. The transceiver according to claim 22, further
comprising:

a sequence transition determining unit for making a transition, in synchronization with said timing signal, from said activation and acknowledge sequence to said transceiver training sequence or from said transceiver training sequence to said channel analysis sequence.

27. The transceiver according to claim 22, wherein, said modulated symbols are transmitted from said transmitting side through both the inside and the outside of said sliding window, and said modulated symbols are used for training of said receiver equalizer by said receiving side only when said receiving side is in a far end cross-talk duration.

28. The transceiver according to claim 22, wherein, during the training of said receiver equalizer in said transceiver training sequence, a step size for updating coefficients of said receiver equalizer is made to be zero in said near end cross-talk duration, or to be a value smaller than the value in said far end cross-talk duration in said near end cross-talk duration at said receiving side, so that said transceiver training sequence is carried out continuously in said far end cross-talk duration and said near end cross-talk duration at said receiving side.

29. The transceiver according to claim 22, wherein said receiving side comprises:

a synchronization symbol detecting unit for detecting a synchronization symbol included in each of superframes which constitute said hyperframe;

an inverse synchronization symbol detecting unit for detecting an inverse synchronization symbol included in said hyperframe; and

an inverting unit for rotating the phase of each carrier signal of the detected inverse synchronization symbol, except for the carrier signal of a pilot tone, by substantially 180° to obtain an inverted inverse synchronization symbol having the same phase as

the phase of each of the detected synchronization symbols;

5 the detected synchronization symbols and the inverted inverse synchronization symbol being used for the training of said receiver equalizer.

10 30. The transceiver according to claim 22, wherein for watching or re-synchronizing the superframe or the hyperframe synchronization, in the case where the synchronization symbol is detected at the receiving side, the synchronization is checked with detection of the next
15 inverse synchronization symbol, and in the case where the inverse synchronization symbol is detected, on the other hand, the synchronization is checked with the next detected synchronization symbol.

20 31. A transceiver to be connected through a communication line, wherein, during timing recover training sequence between said central office and said remote terminal, an inside symbol of a downstream sliding window is formed by a first kind of signal, and an
25 outside symbol of said downstream sliding window is formed by a second kind of signal, said first kind of signal and said second kind of signal being obtained by modulating a carrier signal but being different in phase by a predetermined angle, and

30 said transceiver in said remote terminal recognizes whether a received symbol belongs to a far end cross-talk duration at said remote terminal or a near end cross-talk duration at said remote terminal, by detecting the phase of the output of a fast Fourier transform of
35 said carrier signal, so as to recognize the phase of a timing signal which represents a periodical noise duration.

32. A transceiver to be connected through a communication line, wherein, during timing recover training sequence between said central office and said
remote terminal, an inside symbol of a downstream sliding window is formed by a first kind of signal, and an

outside symbol of said downstream sliding window is formed by a second kind of signal, said first kind of signal and said second kind of signal being obtained by modulating a carrier signal but being different in phase by a predetermined angle, and

said transceiver in said remote terminal recognizes whether a received symbol belongs to a far end cross-talk duration at said remote terminal or a near end cross-talk duration at said remote terminal, by detecting the phase of the output of a quadrature phase shift keying demodulation of said carrier signal, so as to recognize the phase of a timing signal which represents a periodical noise duration.

33. A transceiver in a central office connected through a communication line to a remote terminal, said transceiver comprising;

a phase-locked loop circuit for synchronizing a network timing reference signal, having a frequency higher than the frequency of a first timing signal, with an oscillating signal of a crystal oscillator provided in said central office, to generate a master clock signal; and

a timing signal regenerating circuit for shifting the phase of said first timing signal to provide a synchronization in phase with the phase of said master clock signal so as to generate a second timing signal to be used in said central office.

34. A digital subscriber line communicating system for communicating through a communication line, including:

means for generating a sliding window based on a timing signal representing a periodical noise duration; and

means for discriminating, based on a status of said sliding window, which kind of durations of said periodical noise duration a transmitting data symbol belongs to.

DIGITAL SUBSCRIBER LINE COMMUNICATING SYSTEM
AND A TRANSCEIVER IN THE SYSTEM

5

ABSTRACT OF THE DISCLOSURE

10 A digital subscriber line communicating system for
communicating between a transmitting side and a receiving
side through a communication line, comprising a
hyperframe counter for periodically counting a
predetermined number of continuous transmitting data
symbols constituting a hyperframe synchronized with a
15 timing signal, and a decoder for discriminating, based on
the count value of the hyperframe counter, whether a
transmitting data symbol belongs to a FEXT_r or a NEXT_r.

A sequencer is provided for initializing the status
during an initialization period before starting usual
20 communication. The initialization period includes an
activation and acknowledgement sequence, a transceiver
training sequence, a channel analysis sequence, and an
exchange sequence. According to a single bitmap mode,
the initialization is carried out by transmitting
25 modulated symbols through only inside of said sliding
window. According to a dual bitmap mode, the
initialization except for an S/N measuring sequence in
the channel analysis sequence is carried out by
transmitting modulated symbols through only inside of
30 said sliding window, and the S/N measuring sequence is
carried out by transmitting modulated symbols through
both inside and outside of said sliding window.

Fig.1A

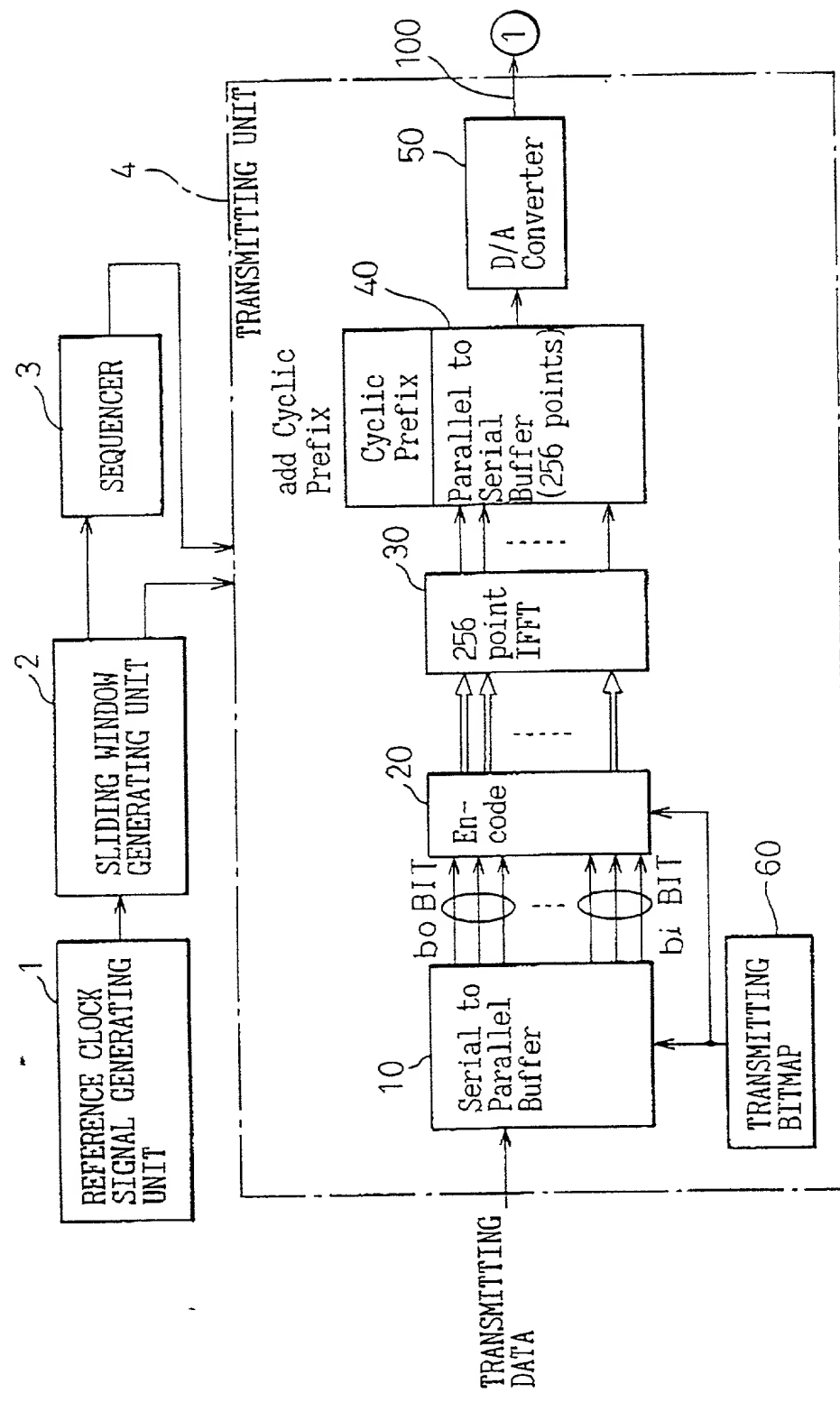
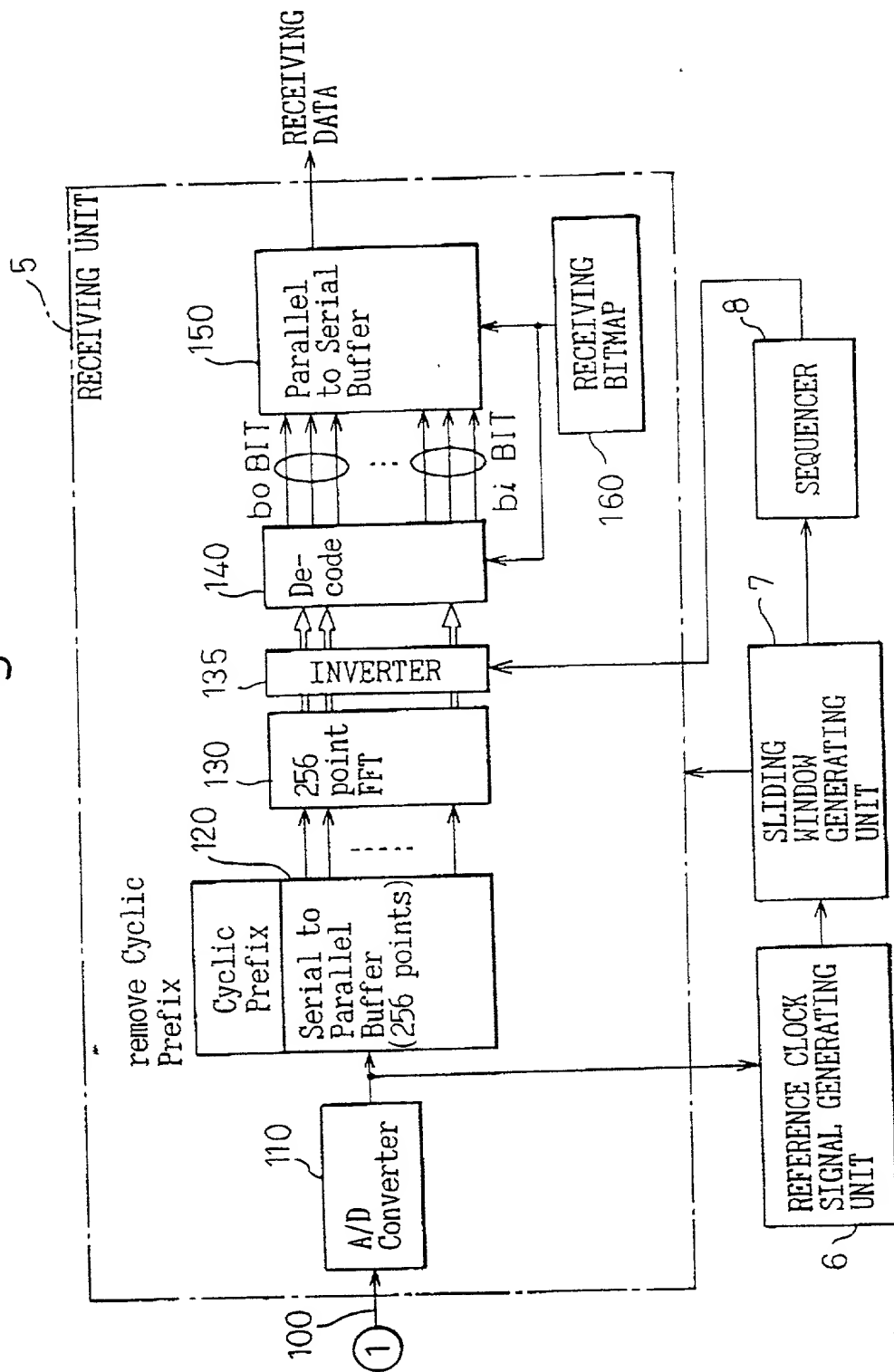


Fig.1B



ATU-C

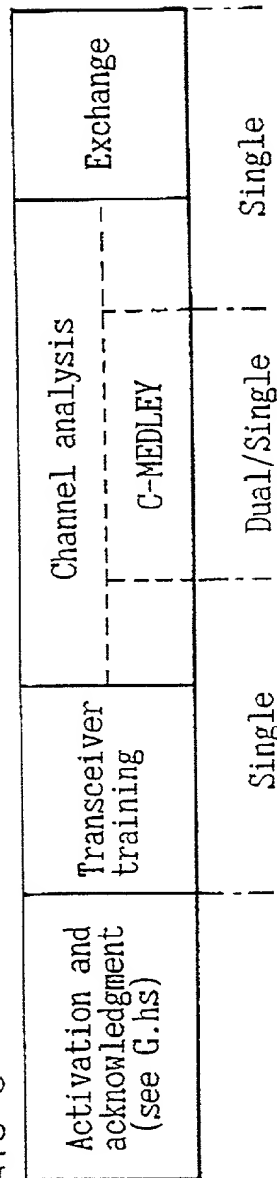


Fig. 4A

5/15

ATU-R

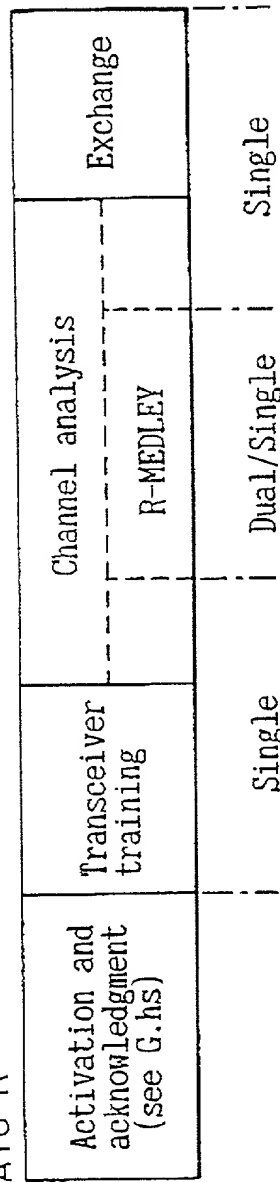


Fig. 4B

Time →

Fig. 5

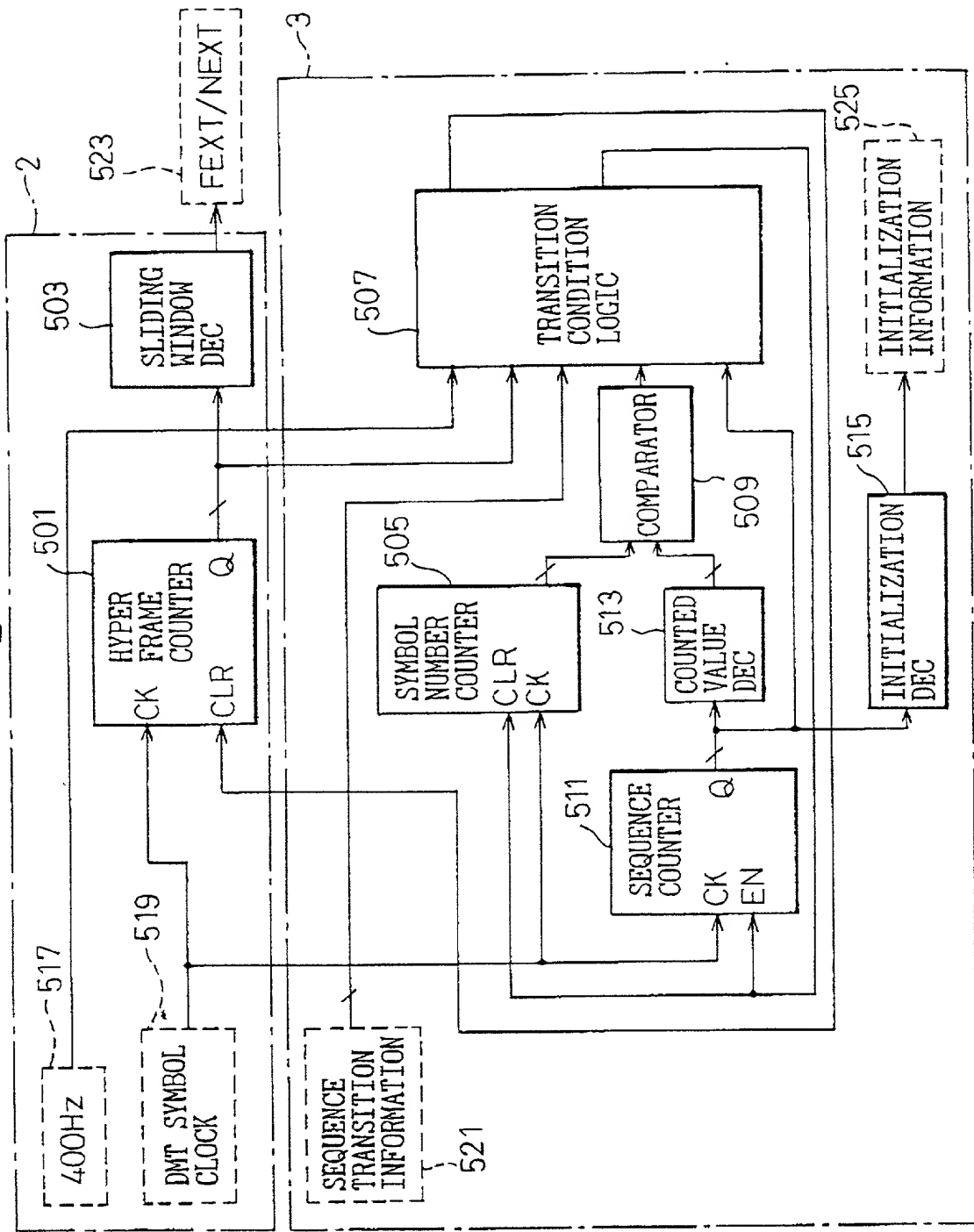


Fig.6

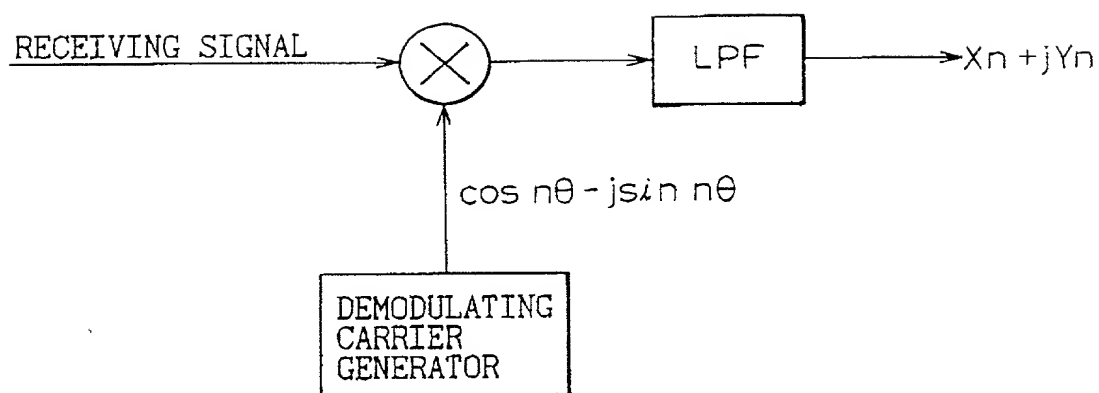


Fig. 7

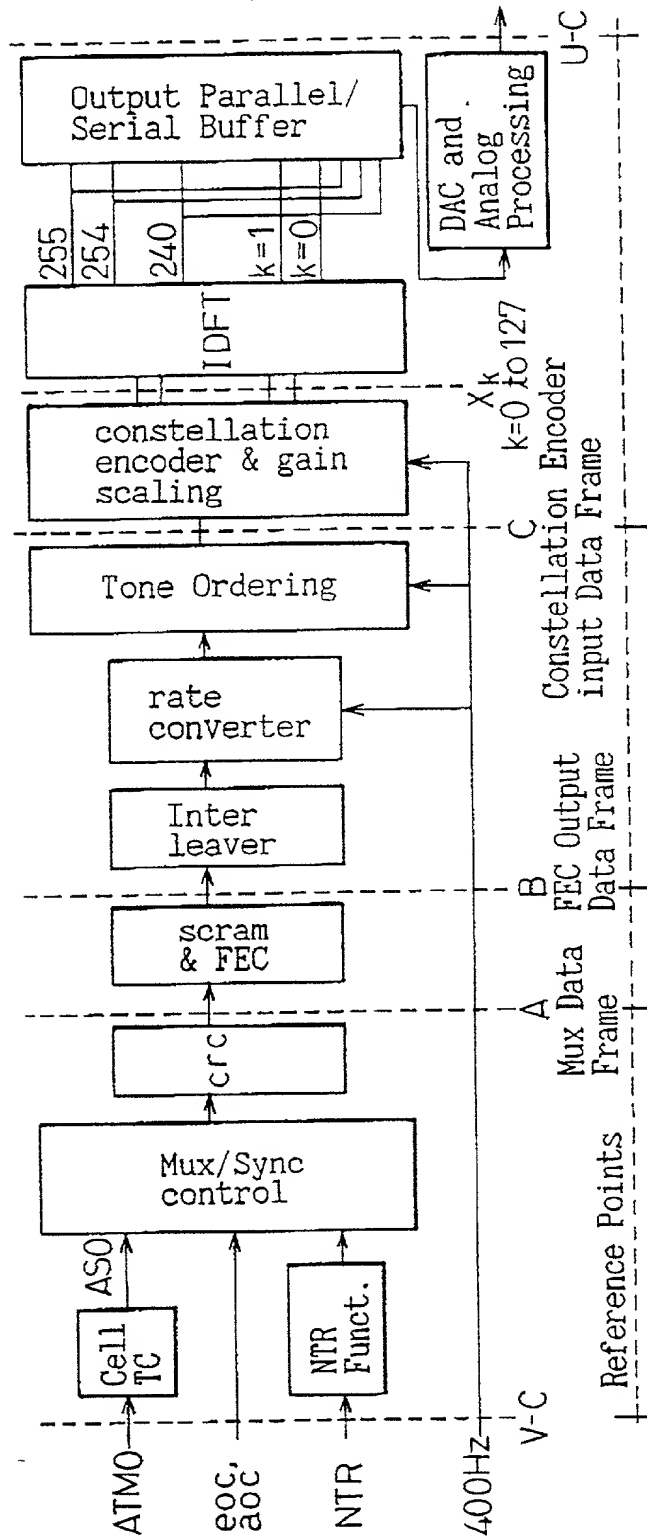


Fig. 8

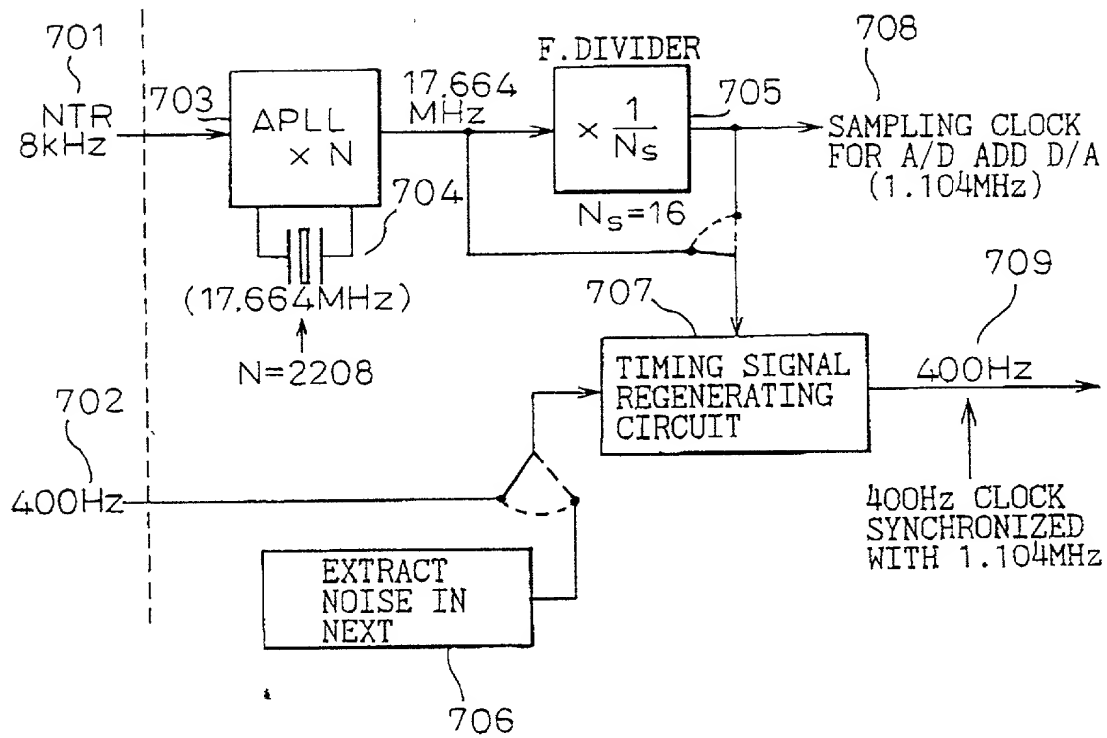


Fig.9

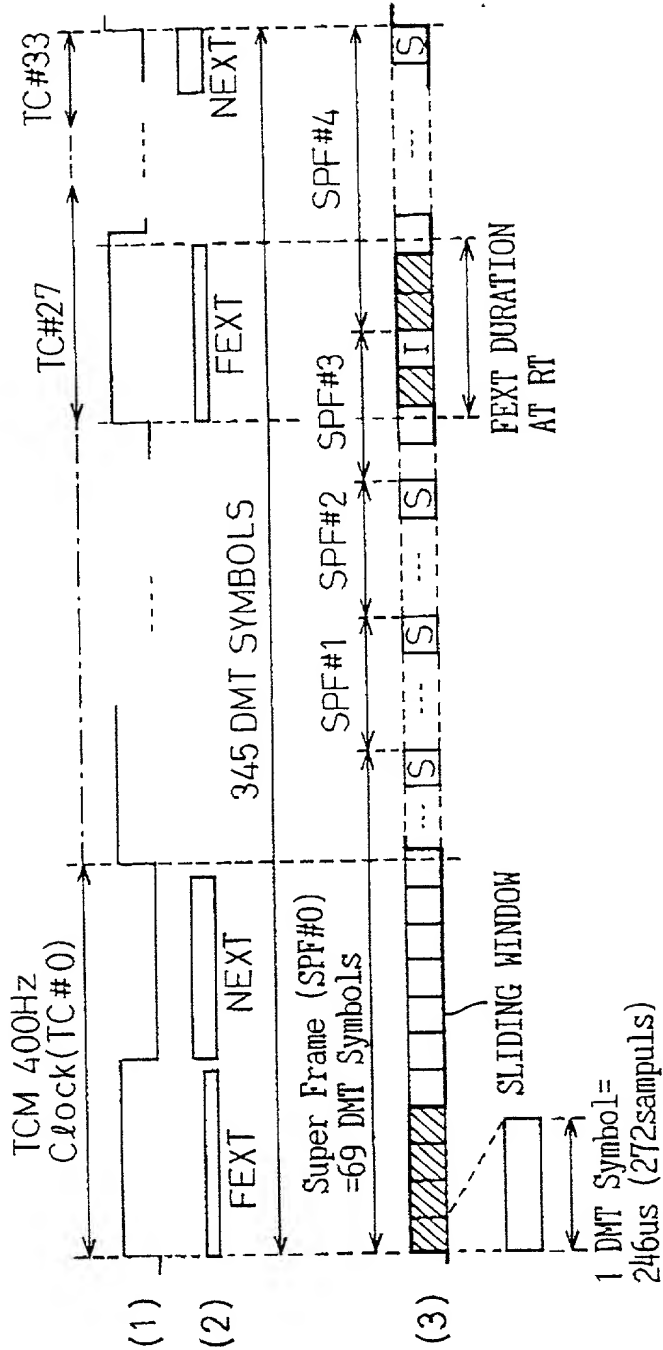
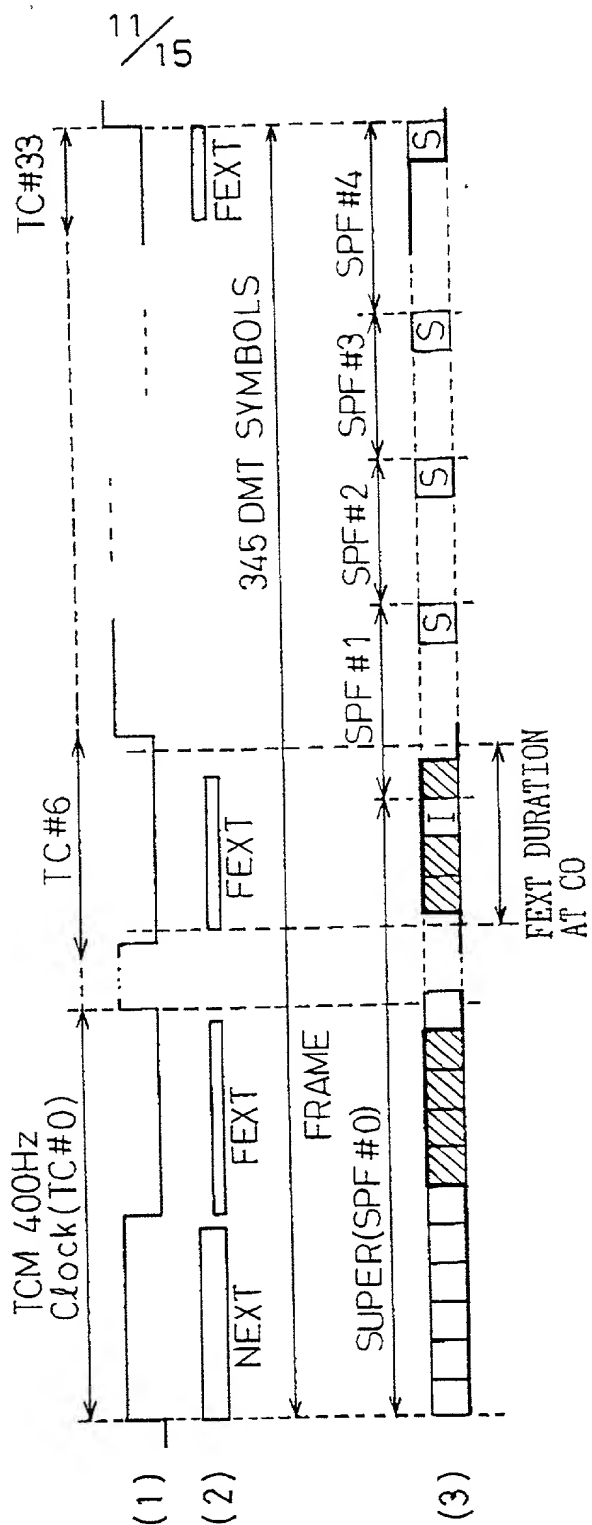


Fig.10



$\frac{12}{15}$

Fig.11

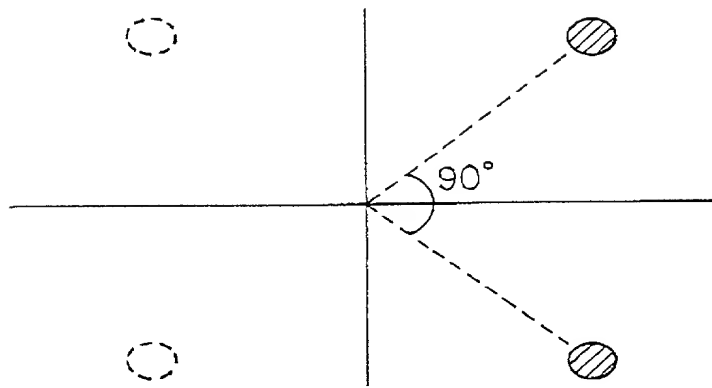


Fig.13A
PRIOR ART

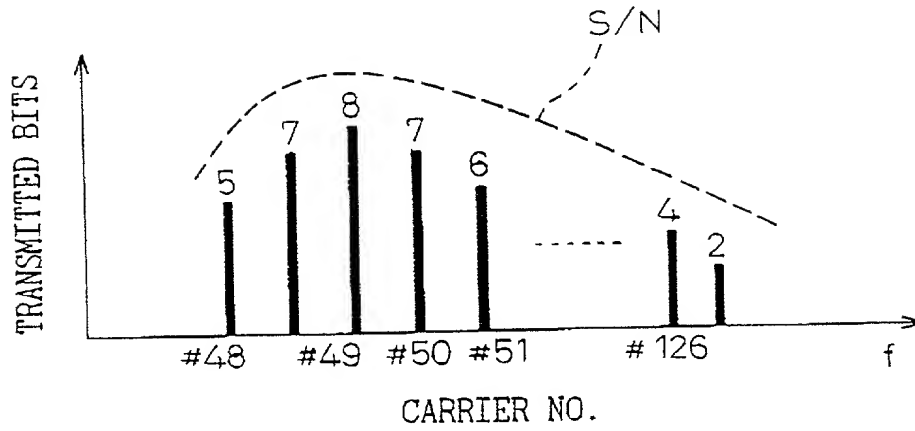
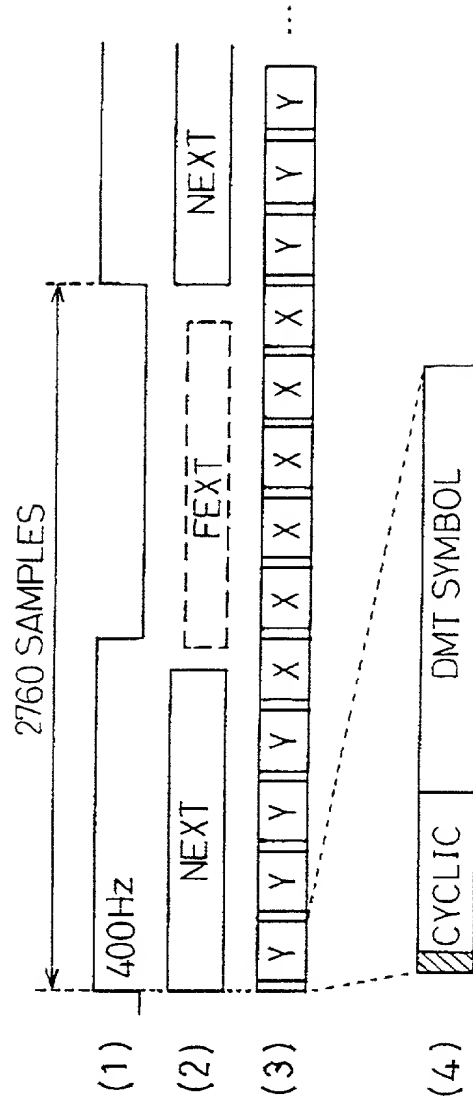


Fig.13B
PRIOR ART

CARRIER NO. i	NUMBER OF TRANSMITTED BITS b _i
0	0
⋮	⋮
48	5
49	7
⋮	⋮

Fig. 14
PRIOR ART



Declaration and Power of Attorney For Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名を発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

DIGITAL SUBSCRIBER LINE COMMUNICATING SYSTEM

AND A TRANSCEIVER IN THE SYSTEM

上記発明の明細書（下記の欄でxが1がついていない場合は、本表に添付）は、

the specification of which is attached hereto unless the following box is checked:

☐ 月 日に提出され、米国出願番号または特許協定条約国際出願番号を _____ とし、
（該当する場合） _____ に訂正されました。

☐ was filed on _____
as United States Application Number or
PCT International Application Number
_____ and was amended on
_____ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understood the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編第1条56項に記載されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Japanese Language Declaration
(日本語宣言書)

私は、米国法典第35編119条(a)-(d)項又は365条(b)項に基づき下記の、米国外の国の少なくとも一カ国を指定している特許協力条約365(a)項に基づく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

Prior Foreign Application(s)

外国での先行出願

10-172464(Pat.AppIn.)

Japan

(Number)
(番号)(Country)
(国名)

19/June/1998

(Day/Month/Year Filed)
(出願年月日)

Priority Not Claimed

優先権主張なし

☐(Number)
(番号)(Country)
(国名)(Day/Month/Year Filed)
(出願年月日)☐

私は、第35編米国法典119条(e)項に基づいて下記の米国外の特許出願規定に記載された権利をここに主張いたします。

(Application No.)
(出願番号)(Filing Date)
(出願日)(Application No.)
(出願番号)(Filing Date)
(出願日)

私は、下記の米国法典第35編120条に基づいて下記の米国外の特許出願に記載された権利、又は米国外を指定している特許協力条約365条(c)に基づき権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第35編112条第1項又は特許協力条約で規定された方法で先行する米国外の特許出願に開示されていない限り、その先行米国外出願提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入予された、連邦規則法典第37編1条56項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

(Application No.)
(出願番号)(Filing Date)
(出願日)(Status: Patented, Pending, Abandoned)
(状況: 特許許可済、係属中、放棄済)(Application No.)
(出願番号)(Filing Date)
(出願日)(Status: Patented, Pending, Abandoned)
(状況: 特許許可済、係属中、放棄済)

私は、私自身の知識に基づいて本宣言書中で私が行なう表明が真実であり、かつ私の入手した情報と私の信じることに基づき表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第18編第1001条に基づき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の表明を行なえば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Japanese Language Declaration

(日本語宣言書)

委任状: 私は下記の発明者として、本出願に関する一切の
手続を米特許商標局に対して遂行する弁理士または代理人
として、下記の者を指名いたします。(弁理士、または代理
人の氏名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint
the following attorney(s) and/or agent(s) to prosecute this
application and transact all business in the Patent and Trademark
Office connected therewith (list name and registration number)

書類送付先

Aaron B. KARAS, Reg. No. 18,923; Samson HELFGOTT,
Reg. No. 23,072 and Leonard COOPER Reg. No. 27,625
Send Correspondence to:

HELFGOTT & KARAS, P.C.
Empire State Building, 60th Floor
New York, New York 10118
United States of America

直接電話連絡先: (名前及び電話番号)

Direct Telephone Calls to: (name and telephone number)

Helfgott & Karas, P.C.
(212) 643-5000

唯一または第一発明者名

Full name of sole or first inventor
Kazutomo Hasegawa

発明者の署名

日付

Inventor's signature

Kazutomo Hasegawa

Date

June 10, 1999

住所

Residence

Kawasaki-shi, Kanagawa, Japan

国籍

Citizenship

Japanese

私書箱

Post Office Address

c/o FUJITSU LIMITED, 1-1,

Kamikodanaka 4-chome, Nakahara-ku,
Kawasaki-shi, Kanagawa 211-8588, Japan

第二共同発明者

Full name of second joint inventor, if any

Seiji Miyoshi

第二共同発明者

日付

Second inventor's signature

Seiji Miyoshi

Date

June 10, 1999

住所

Residence

Kawasaki-shi, Kanagawa, Japan

国籍

Citizenship

Japanese

私書箱

Post Office Address

c/o FUJITSU LIMITED, 1-1,

Kamikodanaka 4-chome, Nakahara-ku,
Kawasaki-shi, Kanagawa 211-8588, Japan

(第三以降の共同発明者についても同様に記載し、署名をす
ること)

(Supply similar information and signature for third and subsequent
joint inventors.)

第三共同発明者	Full name of third joint inventor, if any Yutaka Awata		
第三共同発明者	日付	Third inventor's signature <i>Yutaka Awata</i>	Date June 10, 1999
住 所	Residence Yokohama-shi, Kanagawa, Japan		
国 籍	Citizenship Japanese		
私書箱	Post Office Address c/o Fujitsu Digital Technology Limited, 2-3-9, Shinyokohama, Kohoku-ku, Yokohama-shi, Kanagawa 222-0033, Japan		
第四共同発明者	Full name of fourth joint inventor, if any Takashi Sasaki		
第四共同発明者	日付	Fourth inventor's signature <i>Takashi Sasaki</i>	Date June 10, 1999
住 所	Residence Kawasaki-shi, Kanagawa, Japan		
国 籍	Citizenship Japanese		
私書箱	Post Office Address c/o FUJITSU LIMITED, 1-1, Kamikodanaka 4-chome, Nakahara-ku, Kawasaki-shi, Kanagawa 211-8588, Japan		
第五共同発明者	Full name of fifth joint inventor, if any Nobukazu Koizumi		
第五共同発明者	日付	Fifth inventor's signature <i>Nobukazu Koizumi</i>	Date June 10, 1999
住 所	Residence Kawasaki-shi, Kanagawa, Japan		
国 籍	Citizenship Japanese		
私書箱	Post Office Address c/o FUJITSU LIMITED, 1-1, Kamikodanaka 4-chome, Nakahara-ku, Kawasaki-shi, Kanagawa 211-8588, Japan		
第六共同発明者	Full name of sixth joint inventor, if any		
第六共同発明者	日付	Sixth inventor's signature	Date
住 所	Residence		
国 籍	Citizenship		
私書箱	Post Office Address		

(第七以降の共同発明者についても同様に
記載し、署名をすること)

(Supply similar information and signature for
seventh and subsequent joint inventors.)

THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of: Kazutomo HASEGAWA et al.

Filed: : Concurrently herewith

For : DIGITAL SUBSCRIBER LINE COMMUNICATING SYSTEM AND A
TRANSCIVER IN THE SYSTEM

Serial No.: Concurrently herewith

June 18, 1999

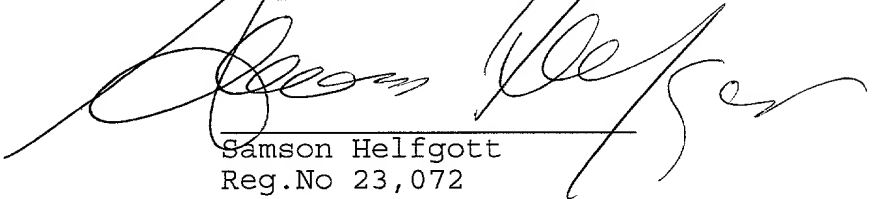
Assistant Commissioner of Patents
Washington, D.C. 20231

SUB-POWER OF ATTORNEY

S I R:

I, Samson Helfgott Reg. No. 23,072 attorney of record
herein, do hereby grant a sub-power of attorney to Linda S.
Chan, Reg. No. 42,400 and Jacqueline M. Steady, Reg. No. 44,354
to act and sign in my behalf in the above-referenced application.

Respectfully submitted,



Samson Helfgott
Reg.No 23,072

HELFGOTT & KARAS, P.C.
60th FLOOR
EMPIRE STATE BUILDING
NEW YORK, NY 10118
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